

LITHIUM IN FIELD AM AND NORMAL A–F-TYPE STARS

P. North¹, F. Betrix² and C. Besson²

Abstract. Preliminary abundances of lithium and a few other elements have been obtained for 31 field Am stars with good Hipparcos parallaxes, as well as for 36 normal A and F stars. Radial and projected rotational velocities were determined as well. We examine the Li abundance as a function of the stellar parameters: for normal stars, it is clearly bimodal for $T_{\text{eff}} < 7500$ K, while Am-Fm stars are all somewhat Li-deficient in this range. The most Li-deficient stars – either Am or normal – tend to be at least slightly evolved, but the reverse is not true.

1 Introduction

The abundance of Li has attracted much attention, especially since the Li gap has been discovered in the Hyades for stars with $T_{\text{eff}} \sim 6600$ K. In the context of radiative diffusion, it is interesting to examine the atmospheric abundance of lithium in stars where such a mechanism is known to be at work from the abundances of other elements, such as calcium, i.e. in the Am stars. Such studies have been carried out especially by Burkhart & Coupry (1991) and Burkhart et al. (2005). Their conclusion was that in general, the Li abundance of Am stars is close to the cosmic value ($\log N(\text{Li}) \sim 3.0$ in the scale where $\log N(\text{H}) = 12.0$), although a small proportion of them are deficient. The latter seem in general to be either evolved stars or, as recently suggested by Burkhart et al. (2005), to lie on the red side of the Am domain, among the ρ Puppis-like stars.

In this poster, we present Li abundances obtained for 31 Am stars and 36 normal A and F stars in the field, all having Hipparcos parallaxes. This sample had been defined before the Hipparcos era, on purely photometric criteria, but with the purpose of testing how far the Li abundance depends on the evolutionary state, i.e. on the surface gravity $\log g$. The Hipparcos data which became available

¹ Laboratoire d’Astrophysique de l’Ecole Polytechnique Fédérale de Lausanne (EPFL), Observatoire, CH–1290 Sauverny, Switzerland

² Formerly at the (now obsolete) Institut d’Astronomie de l’Université de Lausanne, CH–1290 Chavannes-des-Bois, Switzerland

later showed that the photometric luminosity calibrations of Am stars were not very satisfactory (North et al. 1997), but allowed to determine $\log g$ in a more fundamental way. Furthermore, the sample has the advantage of presenting no bias against large rotational velocities.

2 Observations and analysis

All stars were observed at OHP with the Aurélie spectrograph attached to the 1.5m telescope, in April 1993 and in October 1993 and 1994. The grating No 7 was used, giving a resolving power $R = 40000$ in the spectral range $6640 - 6760 \text{ \AA}$. The typical exposure times were between 40 and 60 minutes, the resulting signal-to-noise ratio being between 250 and 400. The spectra were reduced during the observing runs with the IHAP package, and were later normalized to the continuum in an interactive way.

The analysis was made by comparison of the observed spectra with synthetic ones convoluted with an assumed gaussian instrumental profile and with an appropriate rotational profile. The Synspec code (Hubeny et al. 1995) and Kurucz model atmospheres were used to produce the synthetic spectra. The line parameters were taken from Kurucz's *gfiron* list, except of course the parameters for the Li doublet. The effective temperatures were computed from Geneva photometry, while the surface gravities were computed from the Hipparcos parallaxes, by combining them with theoretical evolutionary tracks from Schaller et al. (1998), as explained by North (1998), assuming standard evolution. The microturbulent velocity was either computed from the formula proposed by Edvardsson et al. (1993, eqn 9), for $T_{\text{eff}} < 7000 \text{ K}$, or estimated from the Fig. 1 of Coupry & Burkhart (1992), for $T_{\text{eff}} \geq 7000 \text{ K}$. The abundance of Fe, Ca and a few other elements (in cases of sharp lined stars) were first estimated by visual fits. Then, the Li abundance and the projected rotational velocities were obtained by minimizing the χ^2 between observed and synthetic spectra having various values of these parameters.

3 Results

Fig. 1 shows the distribution of Am stars (full dots) and of normal A-F stars (open dots) in the HR diagram. Evolutionary tracks and isochrones from Schaller et al. (1998) are shown for 4 masses (1.5 to $2.5 M_{\odot}$) and for 3 ages ($\log t = 8.7$ to 9.3) respectively. The stars are well distributed on the whole main sequence band. The lack of Am stars below $T_{\text{eff}} \sim 7000 \text{ K}$ is the well-known limit due to the onset of convection.

Fig. 2 (left) shows the lithium abundance as a function of T_{eff} for Am stars (full dots) and for normal A-F stars (open dots). The most striking feature of this diagram is the bimodal distribution of the Li abundance for $T_{\text{eff}} \lesssim 7500 \text{ K}$, which is reminiscent of a similar distribution of F-type dwarfs in the range $5900 < T_{\text{eff}} < 6600 \text{ K}$ reported by Lambert et al. (1991, Fig. 4). Thus, our data complement that

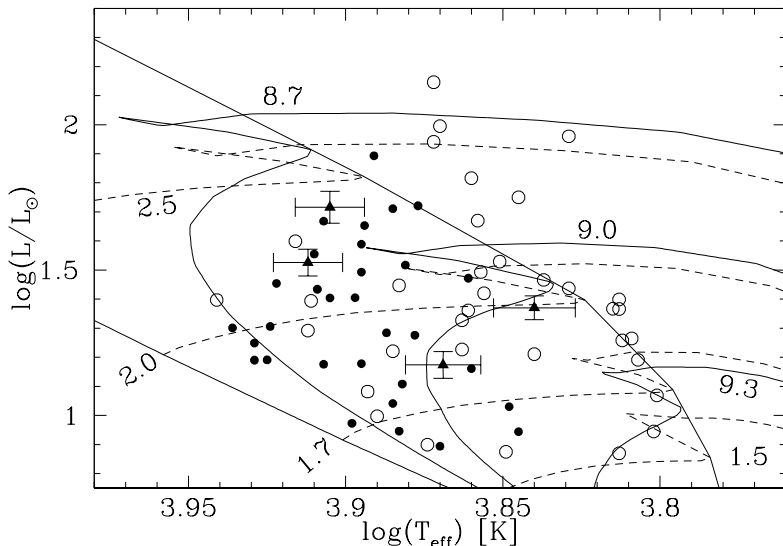


Fig. 1. HR diagram of the Am (black dots) and normal (white dots) stars of our sample. Black triangles (with error bars typical of the whole sample) are stars from Burkhardt et al. (2005, Table 3) not in common with our sample. The error bars were drawn assuming a ± 200 K error on T_{eff} and include, on the vertical axis, the parallax error of Hipparcos.

of Lambert et al. as well as the larger sample of Chen et al. (2001) by extending the results to higher T_{eff} . We have verified that duplicity cannot account for the low apparent Li abundances (even though this might hold for some isolated cases). Restricting the diagram to those stars with $v \sin i < 80 \text{ km s}^{-1}$, the upper branch almost disappears (there are only two normal stars left around $T_{\text{eff}} \sim 6500 \text{ K}$), while the lower one remains intact. This is related to the fact that the upper branch is populated only with normal stars, which rotate more rapidly than the Am stars, while the lower branch is a mix of normal and Am stars. Thus, below 7500 K , all Am stars of our sample are Li deficient. The black triangles refer to the 4 stars of Burkhardt et al. (2005, their Table 3) which are not common to our sample. Their positions are in perfect agreement with the general picture.

Fig. 2 (right) displays the Li abundance as a function of surface gravity. There is no strong trend, but one can notice that those stars (either Am or normal) which are strongly deficient in Li are **all** at least slightly evolved. There is one unevolved star (HD 18769) for which only an upper limit to its Li abundance could be obtained, but this is due to its high T_{eff} (8420 K) and moderately broad lines, and the upper limit is close to the “cosmic” Li abundance, so this is not a significant exception. Thus, we confirm the suggestion made by Burkhardt & Coupry that Li-deficient Am stars are evolved objects, although it seems that all evolved Am stars are not necessarily deficient.

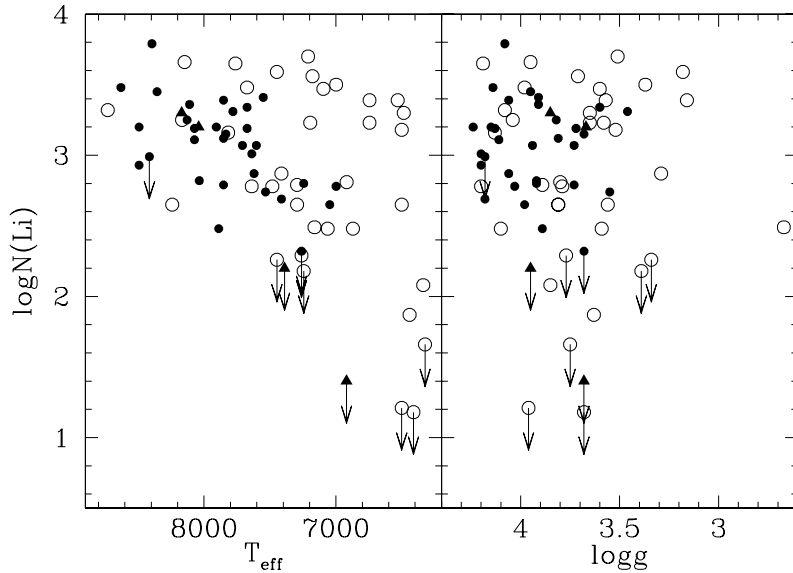


Fig. 2. Left: Li abundance (on the scale $\log N(H) = 12$) of Am stars (black dots) and normal A–F-type stars (white dots) versus effective temperature. Upper limits to the Li abundance are indicated by vertical arrows. Black triangles are from Burkhardt et al. (2005). **Right:** Li abundance versus surface gravity derived from Hipparcos parallaxes. The leftmost arrow refers to the Am star HD 18769, which has $T_{\text{eff}} = 8420$ K and $v \sin i = 46 \text{ km s}^{-1}$, so that only an upper limit to its Li abundance can be obtained. The typical error on $\log g$ is 0.1 dex, while that on $\log N(Li)$ vary from better than 0.1 dex to more than 0.3 dex, depending on T_{eff} and $v \sin i$.

References

- Burkhardt, C., Coupry, M.F., Faraggiana, R., Gerbaldi, M., 2005, *A&A*, 429, 1043
 Burkhardt, C., Coupry, M.F., 1991, *A&A*, 249, 205
 Burkhardt, C., Coupry, M.F., 2000, *A&A*, 354, 216
 Chen, Y.Q., Nissen, P.E., Benone, T., Zhao, G., 2001, *A&A* 371, 943
 Coupry, M.F., Burkhardt, C., 1992, *A&AS*, 95, 41
 Edvardsson, B., Andersen, J., Gustafsson, B. et al., 1993, *A&A* 275, 101
 Hubeny, I., Lanz, T., Jeffery, C.S., 1995, *TUSTY & SYNSPEC – A User’s Guide* (Version 160/24)
 Lambert, D.L., Heath, J.E., Edvardsson, B., 1991, *MNRAS*, 253, 610
 North, P., 1998, *A&A*, 334, 181
 North, P., Jaschek, C., Hauck, B., Figueras, F., Torra, J., Künzli, M., 1997, *ESA SP-402*, p. 239
 Schaller, G., Schaerer, D., Meynet, G., Maeder, A., 1992, *A&AS*, 96, 269